The Emerging Technologies

Sarnoff

Corporate Awards Received by Sarnoff in 1992

Central Jersey Engineering Council
Industry Achievement Award for the
Princeton Engine
(Technical)

International Co-Production Film Market of Florida
Crystal Award
(Technical)

Chamber of Commerce of the Princeton Area
Certificate of Recognition -
50th Anniversary
(Community Service)

Mercer County Board of Freeholders
Freeholder Resolution - 50th Anniversary
(Community Service)

West Windsor Township
Plaque - 50th Anniversary
(Community Service)

New Jersey State Senate
Senatorial Resolution
(Community Service)

New Jersey Capital Area Chapter of American Red Cross
Corporate Award
(Community Service)

DoD Defense Investigative Service
Cogswell Outstanding Industrial
Security Achievement Award
(Government)

Private Industry Council
Governors Partnership Award
(Community Service)

New Jersey Communications, Advertising, and Marketing Association
Astra Award for Sales and Marketing
Video for the Princeton Engine
(Creative/Advertising)

United Way
Silver Award - 1992-3 Campaign
(Community Service)

On the cover: If the American flag were designed today, the story might be told how Betsy Ross used Sarnoff's Princeton Engine, a massively parallel video supercomputer, to manipulate design elements and engineer an image that would identify a nation.

A New Image...the Digital Revolution...

the rapid convergence of video, computing,

and communications...enabling industry

and empowering consumers...a multimedia

potpourri offering new services, new

capabilities, endless possibilities...digital

communications will have a profound impact

on our lives – similar to the introduction of

radio and television...Sarnoff is leading

the digital revolution with breakthrough

technologies in digital signal processing,

optoelectronics, integrated circuit design,

video supercomputing, virtual reality and

collaborative environments...

The beginnings of major events — like great inventions — are seldom clear cut. As the David Sarnoff Research Center continues to expand its business, we will find it hard to single out one instance or event as "a new beginning." Commerce and economic development enjoy a continuum that makes it difficult to determine where "old" business stops and where the new begins.

In 1992, however, the Sarnoff Center reached several important milestones that have put the company at the threshold of a significant new business cycle. In celebrating the Company's 50th anniversary, we marked a half-century of almost unparalleled innovation and achievement in electronic research, even as we look forward to the next decade and the next century.

1992 also marked Sarnoff's 5th year as a client-supported research facility and a subsidiary of SRI International. With that five-year mark, Sarnoff achieved a greater degree of autonomy over its future. Under the terms of Sarnoff's acquisition by SRI from General Electric, GE provided partial funding for the new venture and also held the property deed for the five-year period. On April 1, 1992, GE formally handed over the property to Sarnoff — with no strings attached!

In 1992, we established our first subsidiary company: SENSAR, Inc. SENSAR's mission is to commercialize the "Smart Sensing" technology developed at Sarnoff. Smart Sensing enables a computer to process images and recognize patterns, something that present computers cannot do well. There is an amazing range of applications for this capability, from factory inspection to military uses to medical imaging, and eventually, to personal computing. SENSAR is the first of what we envision as many spin-offs capitalizing on Sarnoff's innovative technology.

Sarnoff's Princeton Engine, a massively parallel video supercomputer, continues to be recognized as a unique machine that can successfully handle the challenges of the 21st century. The capabilities of the Princeton Engine currently meet two of the "Grand Challenges" of the High Performance Computing and Communications Initiative set forth by the Advanced Research Projects Agency (ARPA). The goal of the initiative is to "extend U.S. leadership in high performance computing and networking technologies," and the Princeton Engine offers solutions to problems in the areas of digital anatomy and mapping.

Advanced Digital HDTV, the digital simulcast high-definition television system proposed by the Advanced Television Research Consortium (ATRC), of which Sarnoff is a member, completed a successful round of testing as part of the government process to choose a new TV standard for North America. In addition, our consortium conducted the first digital simulcast under standard broadcast conditions in the United States.

Digital technology, like that used in HDTV, will have a profound impact on all of our lives. The world is "going digital," and our "new beginning" coincides with this important change. All of us at Sarnoff are committed to being leaders in this digital revolution.

Sarnoff's business is growing and 1992 was an encouraging year. Net revenue for the Company was $75.6 million, a 4% increase from 1991. New business bookings were up 38% over 1991, and we had a record backlog heading into 1993. As 1992 came to a close, we were hiring new technical staff to accommodate higher business levels for the coming year. During 1993, we plan to maintain a relatively constant overhead structure and to expand into new marketplaces that need the productivity inherent in our strong technology base. Our overall strategic plan envisions continuing growth, and the achievements of 1992 are a leading indicator that we are on the right track.

1992 Annual Report

James J. Tietjen
President and Chief Executive Officer
SRI International

James E. Carnes
President and Chief Operating Officer
David Sarnoff Research Center

In 1946, the first postwar television receiver — the famed RCA 630 TS, television's "Model T" — entered the American home. The set's brighter picture tube, developed at RCA's Princeton facility, offered viewers much brighter images than prewar receivers.

Technology, like time and tides, waits for no one. The continuing on-rush of technological developments in the latter half of our century seems ever accelerating. Technology today is fast transforming our society and our lives in ways that stagger the imagination.

At the beginning of this century the advent of the airplane enabled us to travel through the air and thus through space; a half century later we had traveled to the moon. Radio and television have made it possible to hear and to see anywhere on our planet. Widespread use of computers and their ability to process information at immense speeds has precipitated an information revolution.

Not since the electric light bulb, however, has anything had the impact on society to equal that of television, particularly color television. Even those who pioneered its development — the scientists and engineers at the David Sarnoff Research Center — could scarcely foresee the transformation it would bring in information distribution, education, entertainment, and in countless other non-broadcast applications.

In 1992, the Sarnoff Center celebrated its 50th anniversary as a research facility. Throughout the year we had opportunities to look back at our distinguished history and to reflect upon some of the pioneering achievements of the Center and its staff.

The growth of the television industry was phenomenal. In 1946, only 10,000 receivers were sold and viewers were limited to a few hours of programming from 11 or 12 stations. Five years later, more than 12,000,000 sets had sold and were served by 107 stations — an interesting historical note when today we are considering High Definition Television and the transmission of hundreds of channels. At the time of publication of this brochure, competing HDTV proponents have joined forces in a *Grand Alliance* to develop a system for high definition television broadcast in the United States. Sarnoff is participating in the Grand Alliance.

At the same time, we also reviewed our more recent past — the last five years during which Sarnoff — now a subsidiary of SRI International — was transforming itself from a corporate research laboratory into an independent client-supported research facility with a host of government and commercial clients throughout the world.

Our long-term vision is to make this new Sarnoff the recognized world leader in electronics research and development, particularly in the technologies for acquiring, processing, communicating, displaying and using electronic images in significant applications.

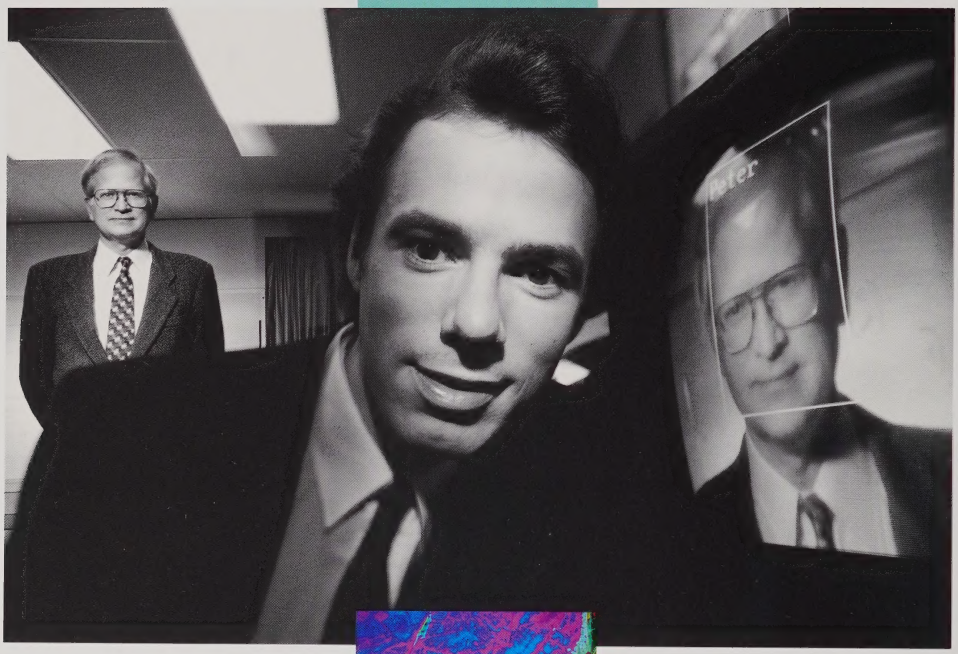
Sarnoff's immediate goals focus on our capabilities in developing electronic products, remaining on the leading edge in solid state technologies, and taking an innovative approach to achieve solutions in information systems.

At present, for example, we are engaged in the effort to evolve a new and enhanced High Definition Television system that will be equal to the demands and desires of the rapidly approaching new century. At the same time, our unique video supercomputer, the Princeton Engine simulates highly complex environments needed for future advances in medicine, engineering, architecture, aerospace — any discipline where innovation is at a premium. Recently Sarnoff announced the formation of a new spin-off company, SENSAR, to capitalize on our "Smart Sensing" computer vision technology developed over the last decade.

Looking back over the last 50 years, we can find it difficult to comprehend all the changes and their implications for today and our society. To look ahead requires the breadth of vision of General David Sarnoff, who once wrote that "Technology, properly guided, can satisfy every material human requirement — feed and clothe the world's multitudes, shelter them, give them work, and guard them from disease. . . If we can muster the wisdom to use the tools which technology has given us, the generosity to devote them to the benefit of all men, the humility to live in harmony with nature, there is little in the spectrum of human progress that is not within our grasp."

Historians of the 21st century, looking back from their perspective, may properly characterize our century as "The Age of Technology." In many ways, Sarnoff researchers embody the spirit of the age. While we may look back to the past for inspiration, we continually have one foot in the present and one foot in the future. We are already among the first citizens of the new world of tomorrow.

Peter Burt (l), Head, Advanced Image Processing, and Keith Hanna, Member, Technical Staff, Information Sciences Research Laboratory, are shown with the face recognition display. The monitor on the right has correctly identified Peter in the background.



Information Systems Research Division

Advanced Digital HDTV

Advanced Digital HDTV, the high-definition digital simulcast television system developed by the Advanced Television Research Consortium (ATRC), was tested in 1992 as part of the Federal Communication Commission's (FCC) process to establish a new television standard for North America. The system demonstrated excellent results, including the best picture quality of all proponent systems.

There are three key attributes that distinguish AD-HDTV from other systems: MPEG ++ compression, a packetized data structure, and two-tiered transmission. The compression scheme is based on MPEG, an internationally recognized standard developed by the International Standard Organization's Moving Picture Experts Group. The MPEG standard has been adapted and improved upon for AD-HDTV, and is called MPEG ++. The benefits of using MPEG include the longevity of a standard, compatibility of other digital television and computer media, and rapid product introduction.

System architecture has been designed using a packetized data structure. The packets carry a mix of video, audio, and auxiliary service data that allow broadcasters to provide a flexible mix of services like fully interactive programming or program augmentation to deliver extra information, sports statistics, or data to enhance the viewing experience. It allows the receiver to become a multimedia tool — more than just television.

AD-HDTV's two-tiered transmission technique ensures reliable, robust system performance. It achieves this by separating information; the most important data is sent simply and effectively on a high priority, or higher power signal, while the remaining data travels on a standard priority carrier. Both are configured to avoid interference with NTSC signals.

The ATRC comprises the David Sarnoff Research Center, National Broadcasting Company, Thomson Consumer Electronics, Inc., Philips Consumer Electronics Company, and Compression Labs, Inc.

National Information Display Laboratory

In 1990, Congress created the Dual-Use program to take sophisticated technologies available to the intelligence community and use them for civil (non-defense) projects. There are many civilian departments of the government that could benefit from this program, and approximately 12 projects are in progress. The National Information Display Laboratory, located at Sarnoff, has been awarded 2 of the 12 projects.

The philosophy behind Dual-Use is that it makes good financial and manpower sense for the intelligence and civilian sectors of government to share existing technology that can be adapted for both. The advantages are obvious: government pays for a program once, taxpayers save money, and communication between sectors of government is improved. In the end, both intelligence and civil communities benefit by getting improved, more efficient capabilities.

The two Dual-Use projects at Sarnoff support the Earth Resources Observation Systems (EROS) Data Center, the research division of the United States Geological Service. One project, called Infobase, will make it easier for Eros Data Center scientists to produce and study the results of their Land Cover Characteristics research, and improve their ability to apply data to specific needs. The second project, Soft Copy Quality Control will provide a better way for scientists to transfer color images from computer displays to hardcopy transparency films. This will be achieved by maintaining monitor performance and ensuring that color hardcopy data closely resembles screen display, thus, preserving the salient information contained in the color images.

Liquid Crystal Displays

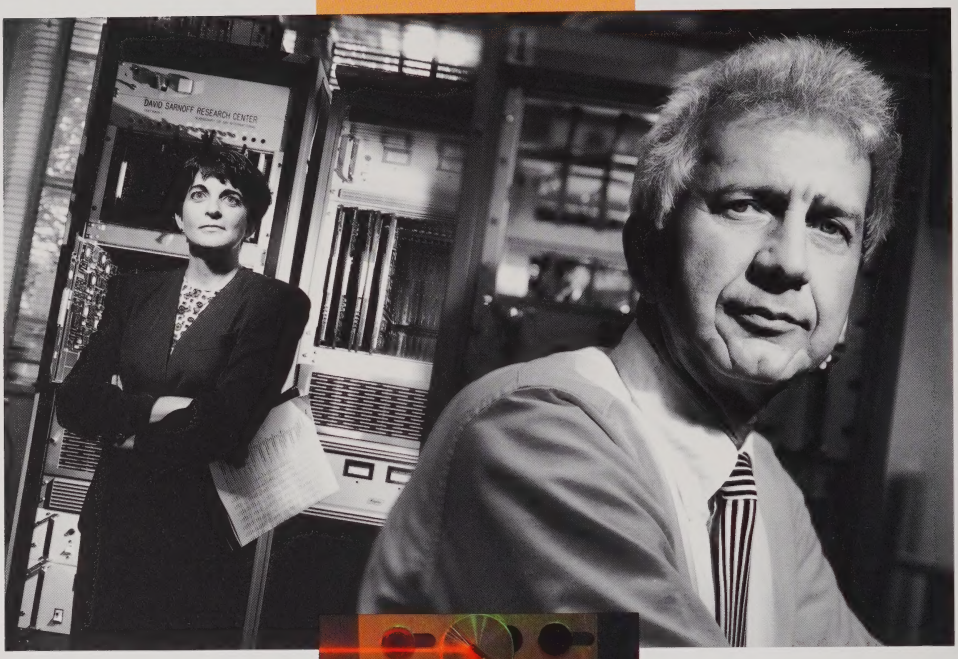
Sarnoff has designed a liquid crystal light valve suitable for color TV projection. This light valve, based on thin film technology, incorporates new advances that make it especially attractive for consumer products. Novel thin film circuitry greatly simplifies the interface between the display and its external driving circuitry. Also, test circuits, which are an integral part of the display, play a significant role in raising the yield of the process and thus lowering the production cost. Tests have shown that, when the Sarnoff display is incorporated in a projection system, it exhibits outstanding contrast ratio and that the image quality is satisfactory for a consumer product.

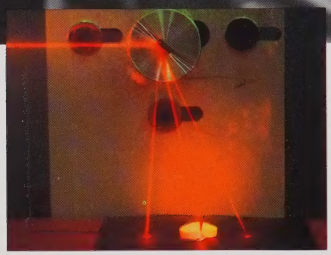
We have designed this display in two versions. The first, which was tested successfully, is suitable for present day analog TV formats. The second, which is now being constructed, is applicable to future high-definition television formats that are transmitted in digital form.

SENSAR

In December Sarnoff announced the development of a new computer vision technology that brings the world one step closer to the "human computer." Sarnoff's patented Smart Sensing technology empowers the computer to perform one of the most basic of human tasks — the ability to recognize images — something that even the most powerful supercomputers cannot do. Smart Sensing is based upon special algorithms that, when coupled with an electronic eye, can enable computers to intelligently respond to what they see in real time.

Kathryn Baughman (l), Manager, Cost Performance Measurement, works with Charles Carroll, Director, Integrated Technology Products Laboratory, to track technical performance and cost status.





This breakthrough differs dramatically from previous computer vision technologies in that it is the first to enable diverse vision tasks. To accomplish this, Smart Sensing encompasses and extends many existing technologies, including object recognition, motion tracking, image compression and fusion, and optical character recognition. Smart Sensing sorts through vast amounts of information in any visual scene, then isolates key characteristics such as movement, shapes, colors, letters, and face patterns. This processing occurs at a rate up to thousands of times faster than any known technology.

Smart Sensing technology significantly extends the opportunities for computerized vision in traditional industries such as personal computers, defense, entertainment, manufacturing, medicine, security, and robotics.

Electronics Systems Research Division

DirecTv™

DirecTv™ will bring true direct broadcast satellite service (DBS) to television viewers in the United States. This high power direct-to-home service will be capable of delivering more than 100 channels of entertainment to 18-inch satellite dishes using MPEG digital compression techniques. Potential DirecTv™ programming includes pay-per-view multichannel movie services, "live" programming of sports and major events, and educational, international or foreign-language programs.

In support of a Thomson Consumer Electronics, Inc. contract with Hughes Communications, Inc., Sarnoff designed and built prototype systems that Hughes and Thomson are using in the business and product development of DirecTv™.

In November, compressed digital video and audio signals were successfully transmitted via a Hughes Communications satellite in a live demonstration at Sarnoff. The video images were displayed in a variety of sizes, resolutions, and aspect ratios. As a result of the test, proof of concept for DirecTv™ was realized more than one year prior to the planned start of service.

Two satellites are scheduled to be launched that will provide coverage for the continental United States. The first satellite launch is scheduled for December 1993. Initial service is scheduled for early 1994.

Emerson

Sarnoff has been chosen by Emerson Electric Co. to provide technology support in electronic design and manufacturing technology as part of the Emerson Advanced Materials Center. Established in 1989, the Advanced Materials Center is a virtual laboratory with a network of research organizations that provide Emerson quick access to specialists, facilities, and new technologies.

During 1992, Sarnoff carried out over 30 projects with Emerson divisions. These projects included electronic product and process development, cost reduction analysis, design reviews, reliability studies, failure analysis, and consultation aimed at solving production problems. Examples of recent projects include concepts for design and packaging of electronics to enhance the performance of universal motors for power tools, design review of a transient voltage surge suppressor, and design reviews of power supplies for new ultrasonic welding and cleaning equipment. Sarnoff also conducted two workshops on critical electronic packaging technologies for Emerson divisions.

Vaccine Plaque Reader

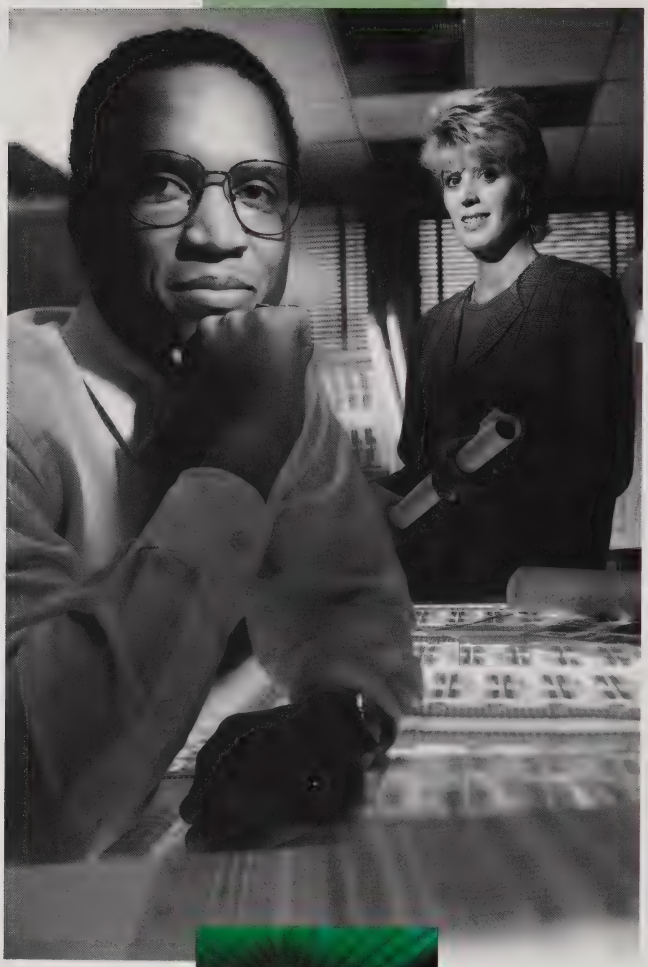
Machine vision technology has been used in a semiautomated device designed, developed, and implemented in a joint effort by researchers at Sarnoff and Rutgers University to test the potency of pharmaceutical vaccines. When a vaccine is tested, a cell layer is grown in a culture dish, subjected to a vaccine and incubated. Following the incubation cycle, the cell layer is stained to highlight areas of infection, otherwise known as plaques. The number of plaques correlates to the potency of the vaccine.

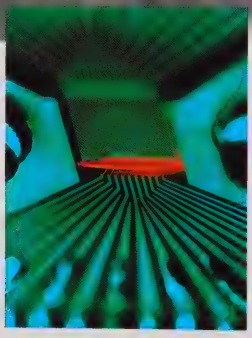
Sarnoff has developed a comprehensive system that identifies each dish, counts plaques, and accurately reports data. A barcode adhered to each dish makes it identifiable throughout the process, and new data is automatically entered into a dish's record over the 7 to 10-day process. Upon completion of the process, dishes are fed to the Plaque Reader, where data are calculated, using algorithms developed at the Center for Computer Aids for Industrial Productivity (CAIP) at Rutgers, and recorded. Potency calculation, as well as reporting into a client's Laboratory Information Management System, is provided by this system through its user interface.

Digital Micro-mirror Device (DMD)

Sarnoff is working with Texas Instruments Incorporated (TI) on a four-year contract received from the Advanced Research Projects Agency (ARPA) and the U.S. Air Force to produce a high-performance digital projection system designed with TI's Digital Micro-mirror Device. The DMD is a micro-mechanical electronic device comprising over 2.3 million micro-mirrors. It switches light mechanically using tiny micro-mirrors that are tilted by means of pivoting hinges in response to instructions from electrodes underneath the mirrors. These electrodes are connected to the silicon memory structure that supports the mirrors and provides the instructions. Employing this integrated approach with the corresponding digital electronics will produce a low-cost, rugged, high-performance device and subsystem that will be at the heart of many digital display systems.

Bill Mayweather (l), Head, Systems and Integrated Circuit Design, and Laura Housel, Senior Technical Associate, Integrated Circuit Laboratory, are both active in integrated circuit design and development.





Sarnoff's role as a subcontractor to TI on the ARPA program is to develop the optics and the video electronics that will help integrate the DMD into the projection system and maximize the DMD's performance. The DMD is optically efficient. Its small size and optical deflection allow for revolutionary optical design and implementation of the projection approaches. The Sarnoff custom optics solution will produce a virtually distortion-free image with colorimetry as good as color CRTs and with an outstanding light efficiency (about a factor of two better than any known light valve projector). The optical design is complete and the design of the video electronics is in progress. Operation of this state-of-the-art high definition, high brightness, and large screen projector is expected during the fourth quarter of 1993.

Solid State Division

GEM

The Generalized Emulation of Microcircuits (GEM) program, an ongoing project with SRI in Menlo Park, focuses on the replacement of obsolete (unavailable) military microcircuits (ICs) with new ones based on state-of-the-art technology. The GEM part is required to emulate the form, fit, and function of the obsolete original part.

In 1992, the GEM program extended its application capability from part-by-part replacement to part replacement by system analysis. This was accomplished through an Air Force-funded study of the problem of obsolete parts affecting the APG-63 Fire Control Radar of the F-15 fighter aircraft. The study showed that a GEM parts replacement program, augmented to the existing logistics infrastructure for the F-15, could provide continued maintenance support and reduce the need for new radars, thus saving DoD more than 500 million dollars. The GEM program will continue to take on increased significance as the need for increasing military cost-savings grows.

High Speed A/D Converters

As the digital revolution continues to gain momentum, the need for faster, more precise analog-to-digital (A/D) converters becomes a critical factor in system improvements. Sarnoff has been a leader in A/D designs for many years, developing flash and subranging A/D architectures in the past, and currently has developed a revolutionary design based on successive sequential approximation (SSA).

The SSA design is a major breakthrough in the development of low-cost, high-performance A/D devices. Innovative device architecture and advanced circuit design techniques have given this complementary metal oxide semiconductor (CMOS) design a unique combination of high speed, high resolution, very low power, and low cost that make it uniquely superior for advanced systems of all kinds, especially as the world moves from analog to digital imagery and communications. Using a mainstream 1 μm CMOS technology, 10 bit resolution at a 40 MHz clock frequency has been achieved at a dissipation of less than 200 mW, while utilizing less than 2 square millimeters of chip area, a factor of 5 less in power required and 10 less in area than the chips available today. The chips are being made available commercially this year.

Visible Imagers

Sarnoff has more than 20 years of experience in the modeling, design, simulation, analysis, and processing of silicon detectors along with the electronic, mechanical, thermal, and optical engineering capability to provide clients standard or customized hardware.

Sarnoff is taking advantage of new business opportunities in the area of high-speed electronic cameras and chips. Imager concepts and designs, originally developed for government requirements, have been successfully introduced into international commercial markets. The imager chips around which this business is developing have very high frame rates (up to 25 times ordinary television frame rate) combined with exceptionally high sensitivity and low noise. Applications include image recording at high speed, optical data acquisition, and signal processing.

Sarnoff's visible imager technology offers 512 x 512 and 1024 x 1024 high-performance, low-noise, back-illuminated sensors that operate from low scan rates to 800 frames per second. A proprietary thinning process provides a 100% fill factor with a high quantum efficiency.

Infrared (IR) Imagers

Infrared silicon imagers are utilized in night vision surveillance, medical imaging, building energy conservation, circuit board interconnects and industrial instrumentation and measurements. Silicon-based charge-coupled device arrays in the visible spectrum have applications for ozone monitoring, earth mineral research detection, soil moisture, weather monitoring, medical imaging, and TV cameras.

Visible and infrared images display different elements in an image, or different kinds of information. Sarnoff's image processing capability permits fusion of both visible and IR to provide images with increased information. Other wavelengths, e.g. radar images (microwaves) fused with the optical images would provide still further information.

Sarnoff's platinum silicide-based technology offers full TV resolution 640 x 480 MOS arrays with electronic exposure control that extends the system's dynamic range to more than 120 dB. The imager operates full frame at 30 frames per second and provides subframe imaging to operate an 80 x 80 subframe at 1000 frames per second.

Milestones ○ Image Orthicon ○ All-Electronic Color TV System ○ Magnetic Core Memory ○ Vidicon Tube ○ Shadow Mask

Picture Tube ○ Solid State Television ○ Magnetic Tape Recording ○ Alloy-Junction

Drift Transistor ○ Superconductive Niobium-Tin Magnets ○ MOS Transistor ○ CMOS

○ GaAs Technology ○ HOMEFAX ○ Liquid Crystal Display Technology ○ ALGaAs Injection Laser ○ CCD Image Sensor ○

COS/MOS Microprocessor ○ First SOS ICs ○ Amorphous Si Solar Cells ○ CCD Comb

Filter ○ Capacitance Electronic Disc ○ COTY-29 Picture Tube System ○ GaAs Space

In 1992, Sarnoff celebrated its 50th Anniversary. It was the first research and development installation in the Princeton corridor, which is now commonly referred to as "Video Valley."

Microwave Amplifiers ○ Multichannel Optical Recording ○ CCD Broadcast Camera ○

External BRAGG Reflecting Laser ○ Surface Emitting Injection Laser ○ Stereo

Broadcast Television Standards ○ DVI Technology ○ ACTV System ○ Grating Surface Emitter (GSE) Laser ○ Princeton Engine ○

Superconducting Microwave Filter ○ Thallium-Based Superconducting Film ○ High-Power, All-Semiconductor Optical Switch

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